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Complex model of e-learning evaluation focusing on adaptive instruction

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Abstract

E-learning evaluation as one of the phases of an e-learning project is rather often the one of the least importance to the developers of e-learning courses. In many cases we can find it performed through the simple means of a student evaluation questionnaire, despite the fact that such a complex matter can hardly be evaluated from just one point of view. This paper deals with a design of a complex model of evaluation with a special attention to adaptive e-learning courses which provide students with personalized/tailored instruction and the importance of which has nowadays indisputable growing tendency. As there are many elements interacting in the process of e-learning instruction, there are also numerous points of view and aspects to be considered within its evaluation. When designing the model of evaluation, we have chosen a systematic approach, defining first all of the interacting elements and determining evaluation aspects and methods of their analysis. Our conclusions presented in this paper are based on the recommendations of experts in pedagogy and didactics, as well as the best practices of e-learning courses design and development.

Keywords: E learning evaluation, E learning personalization, evaluation model, adaptive instruction evaluation;

1. Personalized e-learning

The current growing demand of e learning courses in our country has led to massive development in this area in the last years. At many conferences, seminars or workshops a lot of courses and approaches to this way of education have been presented, being of higher or lower quality, differing in instructional objects usage, media involved, or interface. Considering the number and differences of students made us lay down a fundamental question: How can we deliver the curriculum in a way that would have the best impact on all of them?

Although the idea of personalization has been around for some time, its great potential has not been fully exercised. Such a solution which would adapt to students needs in full extent is not an easy one to implement and there exist no complex methodical guides to secure the expected outcome.

With a team of experts in pedagogy, psychology and ICT in education we have been working on a new model of personalized e learning education, providing the students with tailored courses and instruction within an electronic environment. This model considers three main subjects, modules, of educational interaction: a student, a teacher and an environment, and we are dealing with all of them to achieve the final and complex solution.

The role which a student plays in the typical instruction involves mainly to acquire the knowledge appointed, or in other words to adopt a part of the curriculum, and thus fulfill educational goals. From the personalization point of view, we need to secure that those goals or this knowledge is achieved in a way most efficient and comfortable for

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the student, changing the direction of adaptation from the student adapting to the instruction, trying to master the curriculum, to the curriculum adapting to the student to ease the process of learning.

The teacher in the process of education acts as a provider of knowledge and content, as well as the leader of the instruction, the provider of motivation, etc., every teacher conducting this process in a different way according to his preferences, habits and personal characteristics. This set of features is called a "teaching style". Not all of the diagnosed teaching styles are suitable for the students and what's more, not all of them are suitable for being used in e learning instruction. Since in e learning the teachers are creators, providers of the educational content, their teaching styles directly mirror in the study supporting materials made by their hands. That is why this part of the model needs to be taken into a careful consideration.

In order to provide the educational content in a personalized form and to ensure the adaptability of the whole learning/teaching process we are in need of a highly specialized learning management system (LMS), or to be more accurate, considering it functions, learning management software. The part of the model design, the environment, we do not understand to be only the user interface, the "environment" where the actual learning takes places, but the complex system ensuring this process, providing the content as well as deciding about the way of its presentation according to different student characteristics and based on provided expert rules for such an adaptation.

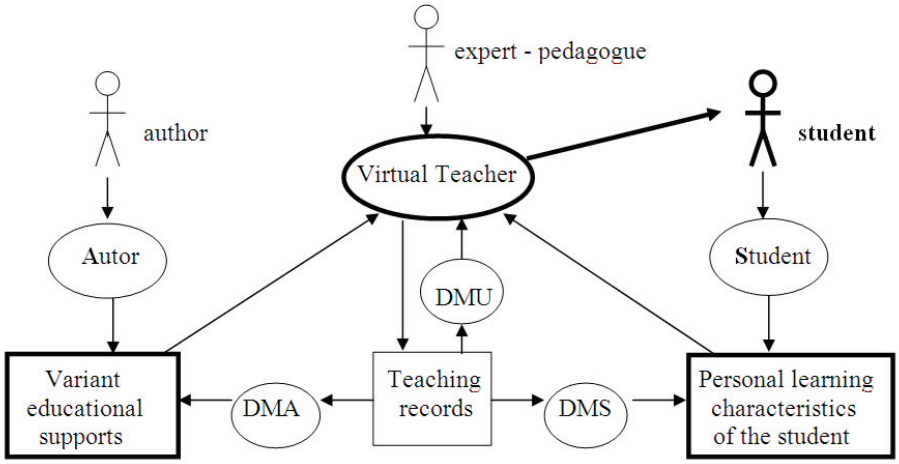

Figure 1 - Theoretical model of the adaptive (intelligent) e learning

By this model we are simulating the typical way of instruction in its ideal way. An ideal teacher is able to optimize the instruction according to his/her students while keeping them motivated and ensuring the knowledge transfer. The modern-day technologies allow us to develop a quality multimedia and interactive contents as well as systems able to simulate such a complex procedure as the work of a teacher is. Thus we can say that the adaptive form of e learning aims to substitute an experienced teacher in the widest possible extent. (Kostolányová & Šarmanová, 2008)

The research of the grounds for the modules of this adaptive e learning model has been further described in detail and published (see the References section).

2. Systematic approach to e-learning evaluation

Together with the highly specific and demanding requirements on the adaptive e learning, also high requirements on its evaluation have risen. E learning evaluation, as we understand it, is not a one-time activity, but rather a complex process parallel to e learning development as well as its implementation up to the point of the end of instruction.

Within another project "E learning Project Evaluation – The Systematic Approach" conducted by our department, we focused on establishing a procedure (procedures) and determining factors that can affect quality, effectiveness and economy of an e learning project. There are many approaches to e learning projects evaluation. Most of theoretical studies and examples of good practice deal with evaluation of study supports and ways of communication between learners and instructors. We presume that the best way of how to prepare the methodology for eLearning evaluation should be the systematic approach, considering also other factors that are not taken into account by existing models of e learning project evaluation. The evaluation model has been based on the "Instructional System Design" (ISD) and its phases, which has been also described as an educational parallel to software development process. (Dvořáčková, Kapounová, Šarmanová, 2011)

Based on the consideration of an e learning to be an "educational project", a detailed set of aspects influencing its quality has been determined, covering all of the phases of an educational process according to the ISD (analysis, design, development, implementation, and evaluation), and laying down the phases of an evaluation project going on simultaneously to them.

The model defines an e learning project to be represented by the development of a set of e learning courses or components and additions or construction of LMS functions, further specifying a course as consisting of relevant content, study system (presenting the content, providing tasks, etc.) and study flow monitoring. (Dvořáčková, Kapounová, Šarmanová, 2011)

Badrul Khan in his "Managing e learning strategies" (2005) publication divides e learning process into two phases:

- content development – planning, design, production, evaluation of eLearning content and resources;
- delivery and maintenance – implementation of online course offerings, on-going updating and monitoring of eLearning environment.

Inspired by these approaches we have determined evaluation areas that need to be taken into consideration, when evaluating e learning (see Figure 2 - Evaluation areas in personalized e learning).

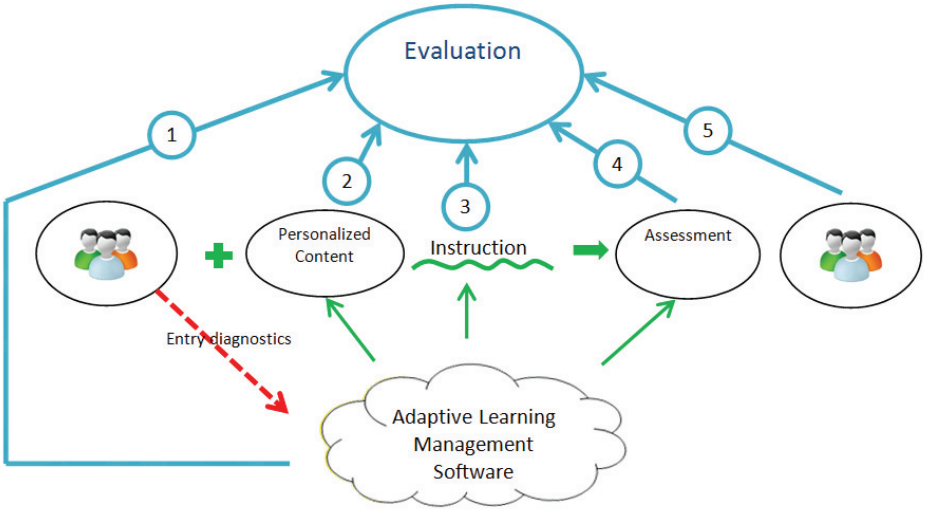

Figure 2 - Evaluation areas in personalized e learning

In Figure 2 the entire process of instruction can be overviewed, including the corresponding evaluation actions. The adaptive learning management software is realizing the instruction based on processing results of entry diagnostics ran on students. The main purpose of this step is to diagnose students' learning styles in order to be able to adapt the instruction. According to the created student profile, the system provides and presents students with suitable content and carries out the instruction. After the instruction students are led to the assessment part of the process and the entire process is either terminated, or repeated in case of students' insufficient assessment achievements. On the evaluation level, all of the elements of the educational process are being assessed within the following evaluation areas which will be further discussed in this paper:

- evaluation of adaptive methods,
- evaluation of study supporting materials,
- instructional system evaluation,
- evaluation of assessment results,
- student evaluation.

3. Specifics of adaptive e-learning evaluation

At the first sight the afore mentioned evaluation areas are applicable on traditional e-learning courses as well as the personalized ones, except for one – the evaluation of adaptive methods. It is quite understandable that should like to evaluate the content of the courses, assess the protocols about student-system interaction and their assessment results. Also the student evaluation is a common part of e-learning evaluation. One may think that there already exist many high quality tools to evaluate these areas and only the adaptive methods need to be taken care of.

The reality is quite the opposite. Each one of these areas needs to be evaluated from the completely different points of view when it comes to adaptive e-learning. Let us skip the adaptive methods evaluation for now, since it is an outstanding are, and let us focus on those that traditional e-learning and personalized e-learning have in common.

When considering the evaluation of study supporting material for example, the first thing, next to its traditional quality aspects, we need to take into account is its suitability for a specific learning type of a student. Since the system needs to be provided with study supports in different versions to suit different students, it is necessary to ensure that each particular part of it is precisely compiled to meet a particular student type "requirements".

Also the instructional system evaluation is closely connected to the adaptive mode. Not only we need to consider the student's learning flow, but it is necessary to evaluate if such a way of studying is efficient, suitable and comfortable enough for the student according to his learning style. What is more, through studying the protocol we can ensure that the entry diagnostics of this learning style had been conducted accurately.

The student assessment at the end of instruction enables us to study the level of acquired knowledge as well as to identify specific insufficiencies within. From the personalization point of view discover, what the causes of these insufficiencies are. Through studying the results we for example get another source of information for the evaluation of study supporting materials.

Very important part of evaluation is the student evaluation. This area of evaluation is often being underestimated, even though it is a very powerful source of information, often proving that the opinions of experts and final consumers – students can differ substantially.

4. Evaluation aspects

Evaluation of e-learning as a complex process involving an e-learning course carried out within an LMS environment and including all of the means, instruments, forms and styles of education and student activities, is such an extent matter to deal with, that we have decided to segment our work into evaluation areas (as previously stated in this paper – see **Error! Reference source not found.**).

Realization of e-learning preconditioned with the provision of an e-learning course which can be defined as a complex educational unit dealing with one subject or one whole topic, or in different ways exactly specified selection of curriculum, with all of its instructional objects, tests, communicational or different activities that are its

essential parts included. (Dvořáčková, Kostolányová, 2011) Although it is with no doubt important to evaluate the courses themselves, when it comes to adaptive e-learning, the whole set of aspects and criteria get a new level of observance, from the student personalization point of view.

4.1. Evaluation of adaptive methods

Based on the adaptive e learning model that we have designed (see Figure 1 - Theoretical model of the adaptive (intelligent) e learning), it was also necessary to design an LMS system capable of all the required functionalities to carry out the adaptation. The system capable of:

- recognizing and recording personal characteristics and learning styles of the students,
- manipulating with adequately structured study supports based on students' needs,
- teaching students in a form and procedure according to their learning styles,
- checking correct understanding of subject matters regularly and testing the skills the students have attained,
- evaluating long-term results and deriving consequences for teaching methods,
- enabling various forms of communication of students and tutors,
- maintaining necessary records on students, subjects, and teachers. (ICITS)

Out of these functionalities it might seem that only the one concerning the actual teaching according to students' learning styles has something in common with adaptive methods. But at a closer look we can find out that more of them are very closely connected.

Within this area of evaluation our aim is to evaluate rules according to which optimally selected elementary parts of curriculum are to be presented to students in a suitable way. In the instruction proper understanding of these is continuously checked through questions and tasks, offering the explanation in a different way, in more detail, with other examples, in case the students fails to prove the achievement of the required level of understanding. Through evaluation the adaptive algorithms of the system should react to those situations immediately and implement changes.

In order to adapt the instruction, what we need first, is a correctly diagnosed student, regarding his/her learning style. Although the diagnostic tools have been designed by experts in psychology and pedagogy, there are a lot of outer aspects that can influence the process of diagnosis, causing inaccurate characteristic description of a particular student. Alerting information about that, and a source for evaluation, can be:

- LMS activity protocol,
- Assessment results (see 4.4 Evaluation of assessment results).

Within their studies students are characterized with a learning style and according to that they are presented with differently compiled materials. However, if they are not comfortable with the presentation, or they feel that a different way of presentation would be more suitable for their understanding, they can easily manually change that, or in other words to ask the system to show a different version. This option is available for elementary object, parts of the curriculum, as well as the whole concept. Also during the course of instruction there is a "dynamic" quality recorded, the "level of comprehension" of the subject matter. These records are regularly amended according to students' responses to review questions and tasks. Finally it is necessary to record the course of study of each student. The records are made about a subject, a chapter, and a paragraph. (ICITS)

This gives us an opportunity to watch the students' preferences in more detail and study the changes of presentation they make, which are recorded in the LMS protocol. This analysis serves as a feedback to the entry diagnosis step, as well as the evaluation of study supporting material.

The protocol also allows us to detect certain patterns in the learning flow, the way the students study through the course. The system suggests a particular way, the order of objects or parts of curriculum, which would be suitable. Again, this might not suit the student and from his moves forward in the course and returns to specific part, we get feedback for the authors to revise the order of content as well as for the adaptive algorithm handling the process.

4.2. Evaluation of study supporting materials

In order to evaluate study supporting material, we first need to determine what it is that we are actually evaluating. It is quite vague to state that it is their quality that we need to secure. The "quality" itself can be understood differently from different points of view – from the professional point of view, regarding the accuracy of the information given, from the technical, considering the technical quality of the piece, or from the didactic point of view, judging the level of didactic practices applied.

To secure that we are not only evaluating the support out of context of its usage, we implement the role of a student, when considering efficiency of the material. Efficiency we understand to be the level of achievement of the educational goals of the material in relation to a student's amount of effort which needs to be applied to achieve them.

In order to secure complexity and validity of evaluation results, we need to again consider all of the aspects. Based on them we determine the following groups of criteria evaluating objects:

1. curricular (evaluating whether the content of the object corresponds with its educational goals and educational goals of the higher levels, continuity based on student's prior knowledge and skills);
2. professional (evaluating actual correctness of the object content information, the extent of the content according to the object goals, the level of detail and proficiency of the content according to its curricular classification, e.g. according to the study programme);
3. didactical (evaluating the way and form of instruction, suitability of the selected type of the object for the particular content, clarity and comprehensibility of the information, tasks incorporation, provision of guidance, level of motivation support);
4. user (evaluating user friendliness, graphic design);
5. technical (evaluating technical functionality of the object, SCORM standard fulfillment, level of technical quality – e.g. level of technical quality of an audio recording in terms of background noise, etc.).

Considering these aspects we start our evaluation at the micro level, progressing with the help of statistical analysis and data mining methods to the macro level of study supporting materials evaluation.

4.3. Instructional system evaluation

Considering the differences of all of the students that take part in the instruction, we have identified combinations of values of student characteristics and determined patterns and corresponding rules according to which the adaptive system manages the instruction.

The system we have been developing is a prototype of its kind which among other things provides sophisticated and systematic feedback on several levels to ensure the instruction is being carried out appropriately. The initial student learning style questionnaire may not always provide precise results due to different factors, for example inaccurate question comprehension, intentional or unintentional incorrect answers, momentary mood influence, etc. Therefore it is necessary to regularly monitor and assess student's activities, course of study and his/her reactions to questions and tasks, and through the means of statistical and data-mining methods analyse the entire report on all of the students' activities. (ICITS)

Through a detailed analysis of the LMS protocol record, we will grant a special attention to the following actions recorded (on the micro as well as macro level):

- work flow,
- time spent,
- skipping instructional objects,
- choosing different levels of detail (than suggested by the system),
- switching to different sensory perception types (within the whole process of learning or just a certain object of interest).

These actions are a valuable feedback source not only for the instructional system, but for the evaluation of study supporting materials and adaptive methods including the entry diagnostics of students. The auto-evaluation algorithms are under the functionality design phase at the moment.

4.4. Evaluation of assessment results

Assessing learning outcomes is concerned with determining whether or not learners have acquired the desired type or level of capability, and whether they have benefited from the educational experience (i.e., have they learned, and how their performance has changed). A measure of learning outcomes requires learners to complete tasks, which demonstrate that they have achieved the standards specified in the learning outcomes. In order to ascertain the most realistic and valid assessment of performance, these task(s) have to be as similar to on-the-job conditions, that is, as authentic as possible. (CEMCA)

Since the study supporting materials used by our adaptive system consist of a number of elementary parts, it allows us to get assessment feedback for partial elements of the study supporting materials as well as the whole concept.

In case of assessment the elementary parts are to be considered the testing questions and tasks. Since they are theoretically a part of the study supporting materials, or at least as closely connected to it as possible, we need to, even in their case, evaluate their quality regarding for example clarity of their statement, correctness of weight specification, specification of targeting, etc., and on a more complex level, the coverage of the piece of curriculum the knowledge of which they are supposed to check, in order to ensure that the results can precisely state the level of knowledge of that particular piece of curriculum.

Within the evaluation of assessment the assessment results are to be analysed with data mining methods, looking for dependent variables. Through that we are able to discover:

- Questions with which features seem to be problematic to students,
  - Specific questions (quality feedback),
  - Question with a certain weight,
  - Questions of which types (multiple choice, created answer, …);
- Whether there is a connection between problematic questions and assigned learning style,
- Whether the student preferred not to answer questions (in case he/she didn't know the correct answer) or preferred to get penalized for a wrong answer (feedback for the attribute of student self-regulation ability),
- Whether the problematic questions covered any specific part of the study supporting materials (feedback to authors of study supporting materials),
- The ratio between correctly answered questions of lower and higher level of weight (feedback for the student attribute of level of detail and approach to studies); etc.

The group of assessment results evaluation criteria is not a closed one. We expect to identify more aspects through educational data mining once the methods are applied on the data acquired from the pilot run.

4.5. Student evaluation

Through analysis and studying of published classifications of learning styles by different authors, student characteristics applicable in e learning have been selected and arranged into following groups:

- Type of sensual perception (visual, auditive, kinaesthetic, verbal);
- Social aspects (prefers working by himself, in a pair, in a group);
- Affective aspects (study motivation);
- Learning tactics:
  - systematicness (order, freedom),
  - way of learning (theoretical deduction, experimenting),
  - procedure of learning (detailistic, holistic),
  - learning approach (depth, surface, strategic),

- self regulation ability (following directions, independent). (ICITS)

Our aim in this area of evaluation is to confirm, with the help of a questionnaire we have prepared in cooperation with experts in psychology, that these students' preferences and requirements have been correctly diagnosed by the adaptive system and thus appropriately met, from the students' point of view not according to the experts' opinions or automated evaluation results.

5. Conclusion

Personalized e-learning supported by adaptive learning management software provides student with higher level of educational support. On the other hand its requirements on a complex evaluation process are unquestionably higher. In our effort we have designed a detailed systematic approach to achieve that, focusing on all of the determined evaluation areas separately.

This approach gives us the opportunity to give our attention to all of the aspects. The final methodology derived from this approach will be the basis for the development of a set of auto-evaluation algorithms providing the developers of such an e-learning system with a complex automatic solution of evaluation.

Since the adaptive learning management software, being a substantially complicated matter, is still under development, we are now focusing on development of this auto-evaluation algorithm, which will be put in use as soon as the LMS is finished and the pilot initiated. So far we have managed to get the personalized e-learning courses content and completed the entry diagnosis, including its final testing.

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